UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY

FOREST INSECT INVESTIGATIONS

TREE MEDICATION AS A CONTROL OF THE MOUNTAIN PINE BEETLE IN WESTERN WHITE PINE

1935 Investigations

By
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Forest Insect Laboratory
Coeur d'Alene, Idaho
August 10, 1936

U. S. GOVERNMENT PRINTING OFFICE: 1928 J 76122

Forest Insect Laboratory
Coeur d'Alene, Idaho
Aug. 12, 1936

Refer to file
Studies C-1B

Dr. F. C. Craighead
Washington
D. C.

Dear Dr. Craighead:

Considerably later than we anticipated I am forwarding Mr. Bedard's final report on the 1935 tree-medication project. However, most of this delay was caused by conditions beyond our control.

This report has been prepared in considerable detail, with a rather large number of tables showing various correlations. Some of these tabulations show fairly definite correlations between the two factors involved, while others are of little value other than their negative results. The chart following page 16 is rather significant in showing that the elapsed time in days between date of attack and medication is not as important a factor as we had previously anticipated. It is possible that last year there might have been considerable error in the recorded date of attack. This year's data, with rather accurately dated attacks, may possibly show entirely different results such as we have anticipated.

An interesting correlation is found on Page 28 (Mortality Versus Rate of Growth). Contrary to our explanation we found that in the slower growing trees with 41+ years of growth the last ½ inch of wood showed a higher mortality than in the more rapid-growing trees. Mr. Bedard has offered an explanation or two of this phenomenon, which seemed to be logical. Dr. Rumbold stated that undoubtedly blue stain would develop more rapidly in fast-growing trees than in slow-growing individuals; therefore, if blue stain is a controlling factor in determining the mortality of bark-beetle broods, then undoubtedly there would be a higher mortality in the slower growing trees.

Trusting we may have your comments on this report, I remain

Respectfully yours,

James C. Evenden
Entomologist

cc to Mr. Miller
Mr. Keen √
Mr. Beal
Mr. Wilford

DICTATED BY MR. EVENDEN BUT SIGNED IN HIS ABSENCE TO AVOID DELAY.

Enc.

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HISTORICAL

During the past several years various investigators have experimented with the possibility of injecting poison into infested trees to kill the bark-beetle broods beneath the bark. As a result of this earlier work tree medication was undertaken in western white pine to develop a cheaper control method for the mountain pine beetle. The first work was done in 1930, and each year thereafter varying amounts of experimental injection work were done. An account of these earlier projects has been given in the six reports listed in the references, so that this report will contain only tabulations and discussions of the results secured from the 1935 tree-medication work which was conducted in the Potter Creek drainage of the Coeur d'Alene National Forest.

The 1935 project was begun on September 3rd and completed on September 27th, during which time a total of 283 western white pine trees infested with the mountain pine beetle were injected with varying dosages of copper sulphate dissolved in water. Both crystalline and powdered forms of this poison were used, but as comparisons show no difference in the results secured from the two, no differentiation has been made between them in this report. Of the 283 medicated trees, one was culled at the time of injection and two were discarded upon examination because they contained only a few basal attacks which had been "pitched-out". The remaining 280 trees have been divided into

"heavy"- and "light"-dosage groups. In the "light" group, each of 255 trees was injected with a solution comprising 8 ounces of copper sulphate dissolved in 4 quarts of water. The remaining 25 trees were injected as follows:

5 trees	- 16 oz.	copper	sulphate +	4 qts.	water	per	tree
5 "	- 24 "	"	"	" "	"	"	"
5 "	- 32 "	"	"	" "	"	"	"

An attempt was also made to inject the outer two inches of wood in 10 trees with a dosage of copper sulphate comparable to that used for commercial wood preservation, using the formula of 8 ounces copper sulphate to one quart of water for every cubic foot of wood to be impregnated. Five trees, ten inches d.b.h., were injected with 32 ounces of copper sulphate on this basis. An attempt to inject 9 1/2 pounds of copper sulphate into each of five trees, 16 inches d.b.h., was unsuccessful, owing to the fact that after the first injection of 32 ounces the tin collar had been so destroyed by the copper sulphate that it was useless to hold more solution. Hence, these five trees will be considered in the two-pound group in the following discussions.

In examining the medicated trees, each tree was felled and one-half square foot bark samples were taken above and below the point of injection, and at twenty-foot intervals along the tree. The trees were first sampled below the collar, then at a height of five feet which was immediately above the collar, then at heights of 25, 45, 65

feet, etc., to the height of infestation. In each sample only the living mountain pine beetle brood was counted. To determine the amount of mortality secured in each tree, the living brood per square foot was compared with the average brood per square foot found in 28 unmedicated check trees which were examined on four sides at ten-foot intervals along the stem. Hence, it is to be understood that the mortality figures used in the following discussions are purely relative and although satisfactory for the purpose of comparing results in the medicated trees, are probably not entirely accurate. Furthermore, past examinations have shown that sometimes the mortality in medicated trees is patchy. Thus, by sampling at 20-foot intervals it is entirely possible that a patch of living brood may have been missed, so that a tree recorded as having 100 percent mortality may possibly have only 98 percent or lower. On the whole, however, the mortality percentages are sufficiently accurate for the purpose of making the comparisons which are the object of this study.

TABULATION AND DISCUSSION OF RESULTS

Heavy-Dosage Trees

As shown in table I, all but one of the heavy-dosage trees showed a mortality of 100 percent. Hence, these trees have merely been listed according to dosage, and no further attempt has been made to correlate mortality with various variable factors.

TABLE I

MORTALITY IN HEAVY DOSAGE TREES

Tree no.	Age attack in days	Percent mortality	D.B.H. inches	Tubes per sq.ft.	Blue stain	Foliage	Dosage in ounces	Temperature °C	Time of injection	Rings last 1/2 inch
222	6	100	16.0	9	none	green	32	13	1:10	29
223	6	100	16.0	9	"	"	32	13	1:20	21
221	11	100	19.5	11	"	"	32	10	11:00	19
224	15	100*	16.0	9	light	"	32	13	1:30	23
230	19	100	24.3	14	"	"	32	15	2:30	13
220	24	100	21.3	12	"	"	32	10	10:30	10
225	27	98*	16.0	9	none	"	32	13	2:00	34
226	27	100*	16.0	9	light	"	32	13	1:45	9
213	30	100	20.2	14	medium	"	32	10	8:15	9
149	54	100	25.5	16	"	faded	32	11	10:15	10
153	9	100*	16.2	12	none	green	24	17	1:00	26
151	11	100	17.0	10	"	"	24	17	12:35	19
232	26	100	25.0	18	light	faded	24	15	3:00	16
209	35	100	16.0	12	medium	"	24	20	3:45	13
188	40	100	19.0	12	"	"	24	11	7:30	30
258	8	100*	18.0	10	none	green	16	9	9:00	16
189	6	100	19.0	11	"	"	16	13	8:00	18
256	9	100	15.5	9	"	"	16	9	9:00	15
143	44	100	19.2	15	medium	"	16	5	8:00	7
234	93	100	16.0	10	heavy	red	16	16	4:00	16
Commercial Dosage Trees										
345	14	100	10.0	10	none	green	32	16	12:45	15
348	54	100*	10.5	5	medium	"	32	16	1:00	38
349	61	100	10.0	9	"	faded	32	16	1:30	47

TABLE I CONTINUED

Tree no.	Age attack in days	Percent mortality	D.B.H. inches	Tubes per sq. ft.	Blue stain	Foliage	Dosage in ounces	Temperature °C	Time of injection	Rings last 1/2 inch
350	27	100	10.0	9	none	green	32	16	1:00	41
351	14	100*	10.0	7	"	"	32	16	1:45	26

* Indicates live brood in stump below point of injection

Tree 225, which showed only 98 percent mortality, is the only one of the heavy-dosage trees which did not yield a complete kill. This tree was exceptionally slow in taking up the poison and a considerable portion of the solution leaked out when the collar was sufficiently weakened by corrosion. An examination of the cores from this tree shows heavy blue stain at the point of injection, medium blue stain at 25 and 45 feet, and heavy blue stain at 65 and 85 feet. This heavy blue stain development probably accounts for the slowness in taking up the poison and the leaking of the collar probably prevented good distribution owing to a lack of sufficient copper sulphate.

Light-Dosage Trees

In table II all light-dosage trees are arranged according to the time elapsing between attack and injection, and in addition other data pertaining to the trees have been included. This table is quite cumbersome and has been included purely as a reference for individual trees. Chart I, which follows table II, gives a picture of the results secured from the 1935 medication.

TABLE II

LIGHT-DOSAGE TREES ARRANGED ACCORDING TO AGE OF ATTACK AT TIME OF INJECTION

Tree no.	Age attack in days	Percent mortal-ity	D.B.H. inches	Tubes per sq.ft.	Blue stain	Foliage	Temper-ature °C	Time of medica-tion	Rings last 1/2 inch
154	6	100	9.0	8	0	G (a)	17	1:30	21
215	6	100	11.4	7	0	G	10	9:00	35
216	6	100	14.0	7	0	G	10	9:00	24
432	6	100	12.0	10	0	G	14	1:20	50
434	6	100	11.0	3	0	G	7	10:10	59
436	6	100	4.0	3	0	G	14	1:30	57
447	6	100	8.0	5	0	G	14	4:15	27
448	6	100	10.0	7	0	G	14	4:30	19
449	6	100*	18.0	17	0	G	14	3:45	16
450	6	100*	16.0	11	0	G	14	4:00	28
451	6	100	10.0	10	0	G	14	4:00	26
452	6	100	14.0	5	0	G	14	4:15	20
453	6	100	18.0	7	0	G	14	4:30	23
240	7	100	6.0	5	0	G	6	9:00	53
241	7	100	9.0	8	0	G	6	9:15	45
250	7	100	11.0	7	0	G	13	1:30	44
190	8	100	8.3	6	0	G	13	8:00	66
242	8	100	11.0	7	0	G	6	9:20	37
248	8	100	8.0	5	0	G	10	10:45	70
249	8	100	13.3	11	0	G	10	11:00	24
257	8	100	8.0	5	0	G	9	9:00	45
259	8	100	12.5	8	0	G	9	9:00	28
261	8	100*	17.0	11	0	G	10	9:30	19
262	8	100	12.0	8	0	G	10	9:20	33
268	8	91*	28.0	14	0	G	13	1:45	12
269	8	100	20.0	16	0	G	11	11:00	10

Tree no.	Age attack in days	Percent mortality	D.B.H. inches	Tubes per sq. ft.	Blue stain	Foliage	Temperature °C	Time of medication	Rings last 1/2 Inch
270	8	100*	16.0	14	0	G	11	11:00	17
273	8	100*	14.0	11	0	G	17	3:30	21
291	8	100*	12.0	9	0	G	7	9:30	29
293	8	100	11.0	7	0	G	7	9:30	47
310	8	100	8.5	4	0	G	17	2:00	49
253	9	100	7.0	2	0	G	13	2:30	52
433	9	100*	20.0	16	0	G	14	1:30	14
192	10	100	18.0	14	0	G	13	9:00	20
201	10	100*	12.7	10	0	G	18	1:05	51
260	10	100*	16.3	11	0	G	10	9:10	13
357	10	100	6.0	3	0	G	17	2:00	63
390	10	92	20.0	12	0	G	16	1:30	11
391	10	100	8.0	5	0	G	16	1:00	27
392	10	100	8.0	7	0	G	16	1:15	52
393	10	80	12.0	9	0	G	16	2:00	34
394	10	100	18.0	14	0	G	16	2:00	18
395	10	100	17.0	12	0	G	16	2:00	38
396	10	100	18.0	12	0	G	16	2:15	12
397	10	100	18.0	11	0	G	16	2:15	26
399	10	100	8.0	5	0	G	15	3:00	29
400	10	100	4.0	3	0	G	15	3:15	38
152	11	100	9.2	7	0	G	17	1:00	43
191	11	100	22.2	14	0	G	13	9:00	19
304	11	100	17.0	13	0	G	17	1:30	17
412	11	100	8.0	4	0	G	2	8:00	33
157	12	100*	14.0	9	0	G	17	2:05	23

Tree no.	Age attack in days	Percent mortality	D.B.H. inches	Tubes per sq. ft.	Blue stain	Foliage	Temperature °C	Time of medication	Rings last 1/2 inch
279	12	100	12.2	10	0	G	15	2:45	30
280	12	100*	16.0	15	0	G	15	3:00	13
281	12	100*	14.5	12	0	G	15	3:30	19
306	12	100*	13.5	11	0	G	17	1:45	15
308	12	100	14.4	10	0	G	17	2:00	37
311	12	100*	12.0	11	0	G	17	2:15	20
312	12	100	15.0	12	0	G	17	2:15	16
254	13	100	16.0	11	0	G	13	3:00	21
283	13	100	18.5	16	0	G	6	8:00	14
287	13	100	12.0	3	0	G	6	9:00	44
288	13	100	14.0	10	0	G	6	8:45	30
289	13	100	23.0	14	0	G	6	9:15	19
292	13	100	16.0	16	0	G	7	9:45	27
301	13	100	10.0	8	0	G	17	1:15	28
231	14	100	6.0	5	0	G	15	3:00	67
237	14	100*	10.0	10	0	G	7	10:00	33
238	14	100*	10.0	10	0	G	7	9:45	26
239	14	100	8.0	8	0	G	7	9:45	34
246	14	100	11.4	9	0	G	10	10:30	19
353	14	81	20.8	14	0	G	17	2:00	19
358	14	100	14.0	9	0	G	17	2:15	17
360	14	100*	11.0	8	0	G	18	2:45	43
361	14	100	11.0	9	0	G	18	2:45	34
364	14	100	13.0	8	0	G	18	4:10	48
302	15	100	8.0	7	0	G	16	1:15	41

Tree no.	Age attack in days	Percent mortality	D.B.H. inches	Tubes per sq.ft.	Blue stain	Foliage	Temperature °C	Time of medication	Rings last 1/2 inch
309	15	100	11.0	8	0	G	17	1:35	55
371	15	99*	14.0	13	0	G	0	8:30	27
398	15	100*	14.0	11	0	G	15	2:45	21
402	15	100	8.0	4	0	G	15	3:45	15
407	15	100	10.0	7	0	G	15	2:50	31
408	15	100	5.0	4	0	G	15	3:00	47
409	15	100	8.0	3	0	G	15	3:30	45
431	15	100*	16.0	11	0	G	6	9:45	27
245	16	100	11.6	10	0	G	10	10:45	30
251	16	100*	16.0	18	0	G	13	2:15	20
252	16	100	10.0	11	0	G	13	2:15	40
255	16	100	9.0	7	0	G	13	3:30	53
430	16	100*	22.0	14	0	G	14	1:10	43
195	17	100*	18.5	12	0	G	14	9:50	14
267	17	100	18.0	12	0	G	11	11:00	26
194	18	100	23.0	10	0	G	15	11:00	30
285	18	100	21.0	12	0	G	6	8:30	12
290	18	54*	17.0	14	0	G	7	9:30	14
305	18	100	18.3	12	0	G	17	1:30	21
389	18	100	18.0	9	0	G	16	1:00	17
243	19	100*	12.2	11	0	G	8	10:00	23
244	19	100	13.4	12	0	G	8	10:00	33
282	19	100*	12.0	11	0	G	15	4:00	24
307	19	100	9.3	7	0	G	17	1:45	56
193	20	100	13.0	10	0	G	13	9:30	25

Tree no.	Age attack in days	Percent mortality	D.B.H. inches	Tubes per sq.ft.	Blue stain	Foliage	Temperature °C	Time of medication	Rings last 1/2 inch
196	20	100	19.0	16	L-10	G	15	10:20	28
207	20	90	21.5	12	0	G	18	3:05	9
376	20	90*	20.6	13	0	G	1	8:45	27
401	20	74*	14.0	11	0	G	15	3:15	14
406	20	80*	12.0	9	0	G	15	4:10	16
219	22	100	10.0	5	L-10	F (b)	10	10:30	63
294	22	100	16.0	10	0	G	7	9:45	19
295	22	100	14.0	10	L-10	G	7	10:30	7
217	23	100	10.0	8	L-10	G	10	9:45	24
218	23	100	10.0	9	L-10	F	10	10:15	45
284	23	100*	14.5	7	L-10	G	6	8:15	22
366	23	100	7.0	4	L-10	G	18	4:20	44
367	23	100	11.0	8	L-10	G	18	4:30	22
204	24	100*	12.0	10	L-10	G	18	1:50	21
205	24	100*	14.0	8	L-10	G	18	2:30	19
247	24	100*	10.4	8	0	F	10	10:30	17
359	24	100	13.0	11	L-10	G	18	2:30	28
411	24	100	6.0	3	L-10	G	15	3:30	36
197	25	100	17.0	11	L-10	F	15	10:40	19
208	25	40*	17.0	7	L-10	F	17	3:05	12
278	25	100*	19.0	12	L-10	G	15	2:30	10
365	25	94	10.0	9	L-10	G	18	4:20	39
429	25	100	11.0	9	0	G	5	9:30	38
303	26	100	16.0	8	L-10	G	17	1:00	23
227	27	100	8.0	7	L-10	G	14	2:15	16
443	27	100*	16.0	14	L-10	G	14	3:30	19

Tree no.	Age attack in days	Percent mortality	D.B.H. inches	Tubes per sq.ft.	Blue stain	Foliage	Temperature °C	Time of medication	Rings last 1/2 inch
444	27	100	16.0	14	0	G	14	3:30	33
403	28	100	10.0	7	L-10	G	15	3:45	24
404	28	100*	10.0	7	L-10	G	15	3:45	18
428	28	100	15.0	9	0	G	6	9:45	48
203	29	100	17.5	16	M-10	F	18	1:27	18
410	29	100	5.0	7	L-10	F	15	3:30	30
435	29	100	12.0	9	L-10	G	14	1:40	34
198	30	100	13.0	13	M-10	F	18	1:00	44
199	30	100	19.0	17	L-10	F	18	12:50	18
202	30	100	15.0	12	M-10	F	18	1:20	27
214	30	100	6.0	4	M-10	F	10	8:15	43
265	30	100*	11.0	8	L-10	G	11	11:00	37
266	30	100	8.0	7	L-10	G	13	1:30	69
228	32	98*	10.0	11	M-10	G	14	2:30	26
229	32	100	6.0	4	M-10	G	14	2:30	24
405	33	100	8.0	5	L-10	G	15	4:00	53
147	34	80	11.0	8	L-10	F	10	9:10	29
148	34	100	7.5	7	M-10	F	11	10:15	51
210	34	100	13.0	8	M-10	F	20	3:30	24
264	35	100	14.0	10	M-10	F	11	10:45	33
274	35	100	15.5	8	M-10	F	17	3:45	36
275	35	98	14.5	8	L-10	F	15	1:45	31
276	35	100*	8.2	5	L-10	F	15	2:00	47
277	35	100	17.7	10	L-10	F	15	1:25	19
379	36	100	8.0	5	L-10	F	2	9:00	75

Tree no.	Age attack in days	Percent mortality	D.B.H. inches	Tubes per sq.ft.	Blue stain	Foliage	Temperature °C	Time of medication	Rings last 1/2 inch
271	37	90	14.0	10	L-10	F	17	3:00	34
272	37	100	14.0	10	L-10	F	17	3:00	30
424	37	100	6.0	3	M-10	F	5	9:30	44
425	37	100	10.0	7	L-10	G	5	9:20	48
426	37	100	18.0	12	L-10	G	6	9:45	13
336	38	100	24.0	11	M-10	F	11	9:30	14
337	38	85	12.0	7	M-10	F	11	9:50	54
338	38	95	14.0	3	M-10	F	11	9:30	19
339	38	87	25.8	10	M-10	F	11	9:50	9
150	40	100	11.0	7	L-10	F	15	11:00	37
332	41	70	23.5	12	M-10	F	10	8:45	7
333	41	0	25.0	11	M-10	F	10	8:40	9
334	41	0	17.3	8	M-10	F	10	9:15	12
384	41	95	12.0	8	M-10	F	7	10:00	20
387	41	100*	14.0	12	L-10	F	8	10:30	11
388	41	100	13.0	7	L-10	F	8	10:30	21
417	41	100	4.0	3	L-10	F	2	8:10	67
437	42	100	18.0	10	L-10	F	15	2:00	21
438	42	100	12.0	9	L-10	F	15	2:00	37
439	42	100	10.0	7	L-10	F	15	2:15	48
440	42	100	8.0	7	L-10	F	15	2:15	51
158	43	100	11.8	5	M-10	F	17	2:15	47
187	43	100*	17.0	10	M-10	F	17	2:25	32
335	43	98	14.3	8	M-10	F	10	9:15	14
370	45	100	10.0	8	M-10	F	0	8:15	37
383	45	100*	13.1	10	M-10	F	7	9:45	19

Tree no.	Age attack in days	Percent mortality	D.B.H. inches	Tubes per sq.ft.	Blue stain	Foliage	Temperature °C	Time of medication	Rings last 1/2 inch
385	45	20	18.0	12	M-10	F	7	10:00	16
386	45	100	6.0	4	M-10	F	8	10:15	74
233	46	100*	13.0	7	H-10	F	15	3:30	41
416	46	100	6.0	4	M-10	F	2	8:10	58
418	46	100	6.0	5	M-10	F	3	8:30	36
423	46	100	10.0	5	M-10	F	5	9:30	59
419	47	100	10.0	7	M-10	F	4	8:55	49
420	47	100	14.0	10	M-10	F	5	9:15	23
421	47	100	6.0	3	M-10	F	5	9:20	66
427	47	100	18.0	14	L-10	F	7	10:00	14
441	47	100	10.0	9	L-10	None	14	3:00	32
442	47	100*	12.0	11	L-10	F	14	3:15	28
445	47	100	10.0	9	L-10	F	14	3:00	35
446	47	100	5.0	4	L-10	F	15	2:45	41
377	51	100	14.0	10	M-10	F	1	8:45	26
297	53	100*	16.0	10	M-10	F	8	11:00	19
298	53	100	14.0	12	M-10	F	8	11:00	28
299	53	100	6.0	5	M-10	F	8	11:00	74
300	53	100*	22.0	12	M-10	F	8	11:00	16
343	54	100	12.0	8	M-10	G	16	1:00	33
344	54	93	14.0	10	M-10	G	16	12:30	50
346	54	100	12.0	8	M-10	G	16	12:45	38
347	54	100	12.0	8	M-10	G	16	12:35	18
354	54	100	10.0	7	M-10	F	17	2:00	49
355	54	100	16.0	10	M-10	F	17	2:00	63
356	54	100	16.0	10	M-10	F	17	2:00	47

Tree no.	Age attack in days	Percent mortality	D.B.H. inches	Tubes per sq.ft.	Blue stain	Foliage	Temperature °C	Time of medication	Rings last 1/2 inch
362	54	100	16.3	10	M-10	F	18	4:00	22
363	54	100	10.0	7	M-10	F	18	4:00	29
369	54	100	12.0	9	M-10	F	0	8:00	31
368	55	100*	11.0	7	M-10	F	0	8:20	36
372	55	0	18.0	12	M-10	F	0	8:00	8
382	55	100	14.0	7	M-10	F	3	9:00	37
413	56	100	10.0	7	M-10	F	2	8:10	39
414	56	100	12.0	11	M-10	F	2	8:20	26
415	56	100	14.0	8	M-10	R	3	8:30	32
422	57	100	8.0	5	M-10	F	5	9:20	49
155	58	100	17.8	5		F	17	1:30	22
211	60	100*	10.0	5	H-10	F	10	7:45	31
212	60	100	8.5	6	M-10	F	10	7:45	61
322	60	100	9.2	7	M-10	F	18	3:30	48
323	60	100	14.7	18	M-10	G	18	3:30	14
340	61	0	12.0	7	M-10	F	12	10:15	18
341	61	0	12.0	8	M-10	F	12	10:20	21
296	65	100	8.0	3	H-10	F	8	11:00	51
314	65	90*	12.0	11	M-10	F	17	2:45	24
315	65	100	19.5	11	M-10	R	17	2:45	28
316	65	100	8.3	5	L-10	F	17	2:30	53
352	66	80*	14.0	10	H-10	F	16	1:30	24
373	67	100*	18.2	10	H-10	R	18	3:00	17
374	67	99	16.2	11	H-10	F	18	3:00	14
375	67	100*	24.0	10	H-10	F	18	3:30	12

Tree no.	Age attack in days	Percent mortality	D.B.H. inches	Tubes per sq.ft.	Blue stain	Foliage	Temperature °C	Time of medication	Rings last 1/2 inch
144	69	100	12.0	9	H-10	F	6	8:30	36
145	69	100	11.0	10	H-10	S	6	8:30	19
146	69	100	11.0	8	H-10	S	8	9:00	58
324	70	70	14.0	10	M-10	F	18	4:35	11
325	70	75*	13.0	11	M-10	F	18	4:30	20
326	70	100	6.0	4	M-10	F	18	4:30	80
327	70	100*	10.4	10	M-10	F	18	4:15	34
328	70	100	10.4	10	M-10	F	18	4:15	19
196	71	100	14.8	5	H-10	R	17	2:00	39
329	71	100*	16.0	14	M-10	F	9	8:00	13
330	71	100*	12.0	8	M-10	F	9	8:00	23
331	71	100*	12.0	8	M-10	F	9	8:15	38
263	72	100	14.0	8	H-10	S	10	10:00	23
380	72	80*	20.0	18	H-10	F	5	9:30	24
381	72	100	11.0	10	H-10	R	4	9:15	53
286	87	100	14.5	9	H-10	R	6	8:00	22
206	90	83*	23.2	7	H-10	R	18	2:35	11
235	94	100	19.5	10	H-10	R	5	8:00	19
236	94	100	16.5	10	H-10	R	5	8:30	31
342	95	95	18.0	11	H-10	R	12	10:30	10
317	100	100	14.0	9	H-10	R	17	3:00	41
318	100	0	14.2	9	H-10	R	18	3:15	19
319	100	0	18.0	9	H-10	R	18	3:15	26

Tree no.	Age attack in days	Percent mortality	D.B.H. inches	Tubes per sq.ft.	Blue stain	Foliage	Temperature °C	Time of medication	Rings last 1/2 inch
320	100	0	12.0	7	H-10	R	18	3:30	23
321	100	100	14.0	11	H-10	R	18	3:30	25

* Living brood below point of injection
(a) Green
(b) Faded

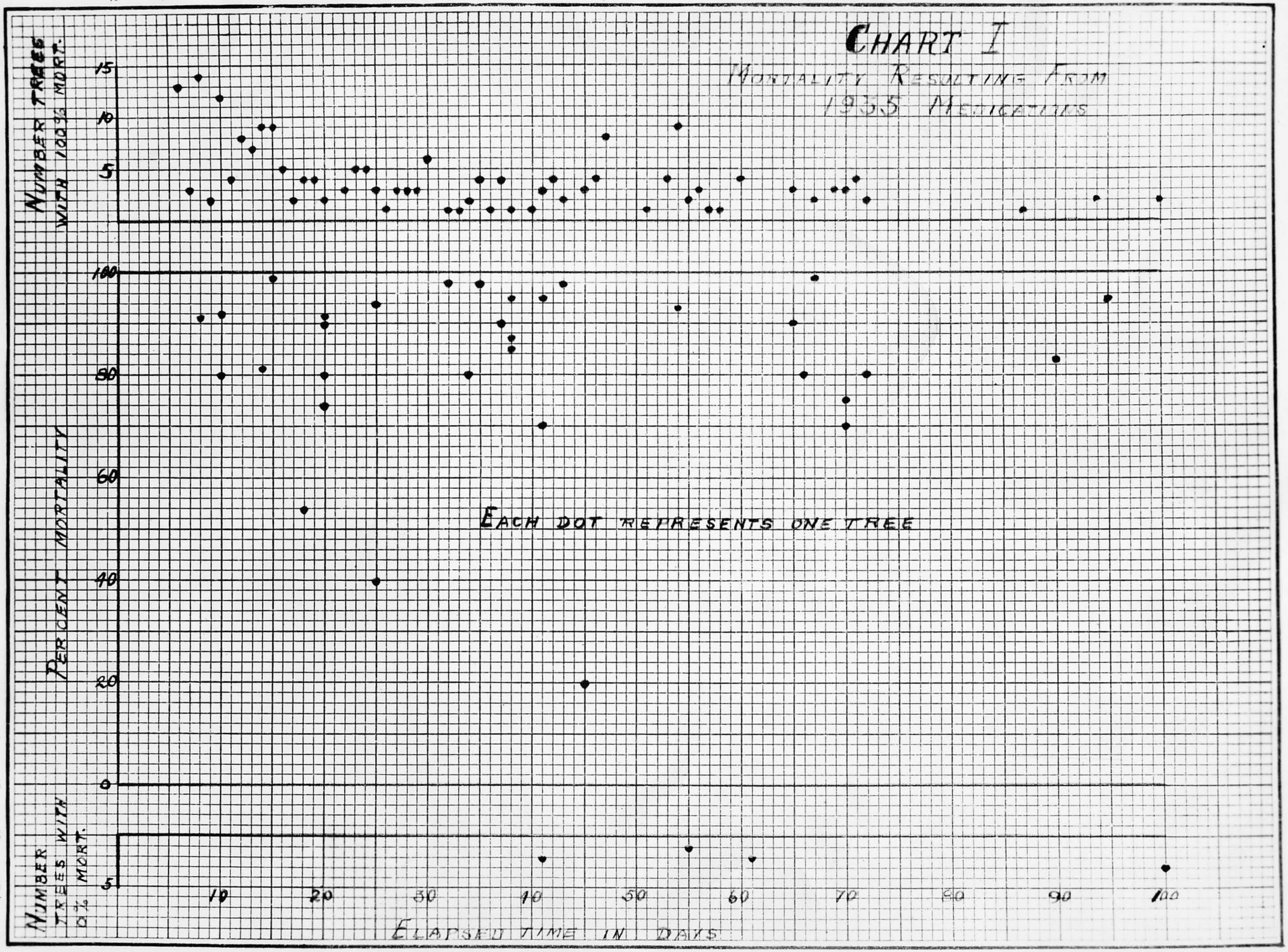
CHART I
MORTALITY RESULTING FROM
1935 MEDICATIONS
NUMBER TREES WITH 100% MORT.
15
10
5
PERCENT MORTALITY
100
80
60
40
20
0
NUMBER TREES WITH 0% MORT.
5
EACH DOT REPRESENTS ONE TREE
10
20
30
40
50
60
70
80
90
100
ELAPSED TIME IN DAYS

Table III presents a summary of table II insofar as mortality is dependent upon the age of attack. The upper portion of the table shows the averages for all 255 of the light-dosage trees and the lower portion presents the averages for only those trees which did not result in 100 percent mortality.

TABLE III

MORTALITY VS. AGE OF ATTACK

	Age of Attack in Days									
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
Percent av. mortality for all trees	99.2	97.8	98.0	96.6	89.4	96.0	84.1	97.1	91.5	61.8
No. trees in group	47	60	33	21	32	27	18	7	2	8
Percent with 100% mortality	93.7	88.4	94.0	66.3	81.3	92.6	61.2	85.8	50.0	50.0
Percent below 100% mortality	6.3	11.6	6.0	33.3	18.7	7.4	38.8	14.2	50.0	50.0
Range in mortality	80-100	54-100	40-100	80-100	0-100	0-100	0-100	80-100	83-100	0-100
Percent av. mortality for trees under 100%	87.6	81.1	67.0	90.4	47.1	46.5	59.1	80	83	23.7
No. trees in group	3	7	2	7	6	2	7	1	1	4
Range in mortality	80-92	54-99	40-94	80-98	0-98	0-93	0-99	80	83	0-95

If the assumption is correct that mortality is dependent upon the distribution of the poison, and the poison distribution is dependent upon the amount of obstruction by blue stain, which in turn is governed by the age of attack and developmental conditions, then a reasonably smooth

curve should result from the age of attack correlation in table II and chart 1. Obviously, the irregularities in these correlations result either from the fact that there is not a sufficient number of representatives in each age group, or from some other pertinent factor or factors influencing blue stain development or mortality which have not been considered in the correlation. Other factors influencing blue stain development will be considered later, but what other factor or factors might influence mortality are purely conjecture at this time. However, in the light of present knowledge as to the actual cause of the mortality, it seems entirely probable that the action of the copper sulphate may be an indirect one in influencing the food supply of the beetles and thus varying concentrations of available food, or materials and organisms affecting food, would cause considerable variation in mortality.

In any event, if the mortality is averaged in larger age groups, a decided correlation results as shown in table IV.

TABLE IV

MORTALITY VS. AGE OF ATTACK WITH LARGER AGE GROUPINGS

	Age of Attack in Days		
	1-25	26-50	51+
Average mortality of all trees	98.1	94.3	88.1
No. trees in group	125	68	62
Average mortality of trees under 100%	80.4	70.4	51.0
No. trees in group	12	13	15
Percent trees under 100%	9.6	19.1	24.1

From the preceding chart and tables, then, it is apparent that although age of attack has an influence upon resultant mortality, the fact that the trees must be grouped in fairly large age classes before a smooth curve results indicates that there are other factors influencing mortality, or that again there are too few samples representing each group. Of those factors which were recorded for each medicated tree, foliage conditions can be eliminated because, being dependent upon age of attack and blue stain development, it would be automatically included in correlations of these two factors. Likewise, insolation and time of injection are important only insofar as they affect temperature which influences the solubility of copper sulphate, as well as the development of blue stain. Insolation and time of injection also affect humidity, which in turn influences the rate of transpiration of the tree; thus these two factors have an indirect bearing on translocation of the poison solution within the tree. Both, however, would be indirectly included in a mortality vs. temperature correlation, so that no further consideration need be given them. Thus, there remain only temperature, intensity of attack, diameter, age of attack, growth rate of the tree, and blue stain as factors which may tentatively be considered as important.

In table V mortality has been compared with temperature both for all 255 light-dosage trees and for the 40 trees which did not result in 100 percent mortality.

TABLE V

MORTALITY VS. TEMPERATURE
AT TIME OF INJECTION

Temperature in °C	0-5	6-10	11-15	16-20
Average percent mortality for all trees	95.1	92.4	94.4	93.2
Number of trees in group	28	66	79	82
Average percent mortality for trees below 100%	67.2	52.1	73.0	68.0
Number of trees in group	4	8	11	17
Percent total trees below 100%	14.2	12.1	13.9	20.7

In table V there is no apparent relationship between mortality and the 1935 temperatures at the time of injection, either when all trees are averaged or when the 40 low-mortality trees are averaged separately. In the fourth horizontal column, which shows the number of low-mortality trees in each temperature group, there is an apparent increase in the number of low-mortality trees as the temperature increases. It is at once obvious, however, when the percentage of low-mortality trees is computed for each group, as shown in the next column, that this apparent increase results simply from the fact that more trees were treated at the higher temperatures.

It is apparent then that temperatures during the 1935 season were not low enough to affect the solubility of copper sulphate sufficiently to inhibit the distribution of the poison in the trees. It is entirely possible, however, that temperatures during some seasons may be important from the solubility standpoint.

A similar table has been made of table VI to compare mortality with the intensity of mountain pine beetle attack.

TABLE VI

MORTALITY VS. INTENSITY OF ATTACK

Pitch tubes per square foot	1-5	6-10	11-15	16-20
Average percent mortality	99.8	93.6	92.4	98.1
Number of trees	45	133	64	13
No. trees below 100%	1	21	17	1
Average mortality for trees below 100%	95	59.6	71.6	80
Percent total trees below 100%	2.2	15.7	26.5	7.6

Unfortunately the intensity of attack was determined at the base of the trees only, and as a result pitch tubes per square foot appear to have no effect on mortality. It is to be expected, however, that if the intensity of attack were determined for various positions of the tree, it would be found to have an effect upon the resultant mortality because the amount of blue stain innoculation by the beetles should affect the intensity of blue stain, which in turn limits poison distribution. Likewise, if it were possible to determine temperature at various points on the tree, one would expect to find a positive correlation, because temperature influences blue stain development.

However, temperature and intensity of attack show no effect on mortality for the 1935 project, and having thus eliminated them,

temporarily at least, there remain diameter, age of attack, growth rate of the tree, and blue stain to be considered. In table VII the first three factors have been tabulated with age of attack and diameter as the variables and rate of growth as the constant.

TABLE VII

MORTALITY VS. AGE OF ATTACK AND DIAMETER

D.B.H. in inches	Rings last 1/2 inch	Age of Attack in Days: 1-25		26-50		51+	
4-9.9	41+	100		100		100	
	No. trees		18		13		7
	21-40	100		100		No trees	
			8		3		
	1-20	100		100		No trees	
			1		1		
10-15.9	41+	100		98.5		98.6	
			11		10		5
	21-40	99.1		98.3		89.8	
			33		20		25
	1-20	96.7		97.6		67.1	
			14		5		7
16-21.9	41+	No trees		No trees		100	
							2
	21-40	99.1		100		80	
			12		4		6
	1-20	94.0		79.7		84.8	
			24		9		7
22-27.9	41+	100		No trees		No trees	
			1				
	21-40	100		No trees		No trees	
			1				
	1-20	95.5		64.2		94.3	
			2		4		3

Here again in table VII it is quite apparent that either there is not a sufficient number of individuals to represent each diameter group, or that diameter plays no part in the mortality secured by injecting an infested tree with an aqueous solution of copper sulphate. Further comparisons to determine the importance of diameter are shown in tables VIII, IX, X, XI, and XII.

TABLE VIII

MORTALITY VS. AGE OF ATTACK AND DIAMETER
FOR 40 TREES WITH MORTALITY BELOW 100%

D.B.H. in inches	Rings last 1/2 inch	Age of Attack in Days					
		1-25		26-50		51+	
4-9.9	41+						
	No. of trees						
	21-40						
	No. of trees						
	1-20						
	No. of trees						
10-15.9	41+			85		93	
	No. of trees				1		1
	21-40	91		91.5		42.5	
	No. of trees		3		4		4
	1-20	77		96		36.2	
	No. of trees		2		3		4
16-21.9	41+						
	No. of trees						
	21-40	90				40	
	No. of trees		1				2
	1-20	71.4		10		64.6	
	No. of trees		5		2		3
22-27.9	41+						
	No. of trees						
	21-40						
	No. of trees						
	1-20	91		52.3		83	
	No. of trees		1		3		1

TABLE IX

MORTALITY VS. DIAMETER

D.B.H. in inches	4-7.9	8-11.9	12-15.9	16-19.9	20-23.9	24-27.9	28-31.9
Av. percent mortality for all trees	100	99.7	92.7	90.7	92.5	71.7	91
No. trees in group	22	75	82	53	15	4	1
Av. percent mortality for trees below 100%		90.6	68.5	38.5	83.7	43.5	91
No. trees in group		3	19	8	7	2	1
Percent trees below 100%	0	4.0	23.1	15.0	46.6	50.0	100

TABLE X

MORTALITY VS. DIAMETER WITH
SMALLER DIAMETER GROUPS

D.B.H. in inches	4-9.9	10-15.9	16-21.9	22-27.9
Av. percent mortality for all trees	100	95.2	90.6	87.0
No. trees in group	52	130	60	13
Av. percent mortality for trees below 100%		71.5	57.0	66.2
No. trees in group		22	13	5
Percent trees below 100%	0	16.9	21.6	38.4

TABLE XI

MORTALITY VS. DIAMETER AND RATE OF GROWTH

D.B.H. in inches	4-9.9			10-15.9			16-21.9			22-27.9		
Rings last 1/2 inch	41+	21-40	1-20	41+	21-40	1-20	41+	21-40	1-20	41+	21-40	1-20
Av. percent mortality for: all trees	100	100	100	99.1	96.3	87.9	100	93.1	88.9	100	100	84.6
No. trees in group	38	11	3	25	79	26	2	19	39	1	1	11
Av. percent mortality for: trees below 100%				89.0	73.5	65.2		56.6	57.1			66.2
No. trees in group				2	11	9		3	10			5
Percent trees: below 100%	0	0	0	8.0	13.9	34.6	0	15.7	25.6	0	0	45.4

TABLE XII

MORTALITY VS. AGE OF ATTACK AND DIAMETER

	D.B.H. in inches	Age of Attack in Days: 1-25	No. trees	26-50	No. trees	51+	No. trees
Average percent	4-9.9	100	27	100	17	100	7
mortality for	10-15.9	98.7	58	98.2	35	86.7	37
all 255 light-	16-21.9	95.7	36	86.0	13	84.9	15
dosage trees	22-27.9	97.7	4	64.2	4	94.3	3
Average percent	4-9.9						
mortality for	10-15.9	85.4	5	81.1	8	45.3	9
40 trees under	16-21.9	74.5	6	10	2	54.8	5
100% mortality	22-27.9	91	1	78.5	2	83	1

In the preceding five tables mortality has been compared with diameter in various ways. In table VIII the 40 trees which showed less than 100 percent mortality have been arranged to show the relationship between mortality and age of attack and diameter. In this table rate of growth has been used as a constant in each diameter group. It is quite apparent in table VIII that lack of any apparent positive correlation is entirely owing to the small number of individuals representing each group. Table XII represents a combination and condensation of tables VII and VIII by eliminating rate of growth. In table XII there is a slight indication that both diameter and age of attack have an influence upon mortality. This is not true of the lower portion of the table in which the 40 low-mortality trees have been averaged for the various age and diameter groups. In the upper portion of the table, however, in which the mortalities for the 255 low-dosage trees have been averaged, there is good indication of a relationship with age in the 10-15.9 and the 16-21.9 diameter groups as well as a relationship with diameter, particularly in the 26-50 age group.

Table IX represents a single correlation of mortality with diameter. Here, there is a further indication that diameter has some influence upon the resultant mortality, except where there are too few individuals to represent the diameter group. To eliminate the irregularities in table IX, table X has been compiled by averaging the mortalities in larger diameter groups. In this table an ex-

cellent relationship is shown which indicates that diameter does have an influence upon mortality when western white pine trees are injected with a dosage comprising 8 ounces of copper sulphate and four quarts of water. Considering diameter further, the 280 medicated trees had an average diameter of 13.4 inches; the 215 light-dosage trees which showed 100 percent mortality averaged 12.5 inches D.B.H., while the 40 light-dosage trees with mortality below 100 percent averaged 16.2 inches in diameter. In table XI mortality has been compared with diameter as in table X, except that each diameter group has been subdivided into growth classes. In this table, although diameter still maintains its positive position, rate of growth appears to be the more important of the two. In any event, the problem presented by the relative amounts of poison required for different tree sizes will be eliminated if trees are injected with heavier dosages in an attempt to impregnate an outer shell of wood with an amount of poison comparable to that used in commercial wood preservation. If, however, the commercial dosages prove impractical in western white pine, it will be necessary to determine the dosages necessary for different diameters, and in all probability for different-aged attacks.

Of those factors considered so far, it has been shown that age of attack and tree diameter have some influence upon mortality. There remain, then, rate of tree growth and blue stain yet to be considered in determining the limiting factors of mortality for the 1935 project.

Considering growth, the average number of rings in the last half-inch of wood for all medicated trees is 30.8. For the light-dosage trees which resulted in 100 percent mortality the average number of rings is 32.8, while those trees with mortality under 100 percent average only 20.4 rings in the last half-inch of wood. Also, in the preceding tables it has been noted that growth apparently has an important influence on mortality. In table XIII a single correlation on growth has been made with no regard for other factors.

TABLE XIII

MORTALITY VS. RATE OF GROWTH

Rings last 1/2 inch	41+	21-40	1-20
Average mortality for all trees	99.6	96.1	88.4
No. trees in group	66	110	79
Average mortality for trees under 100%	89.0	69.9	61.2
No. trees in group	2	14	24
Percent trees under 100%	3.0	12.7	30.3

From table XIII it may be said that rate of tree growth has an important influence upon mortality. It is apparent that the slower the rate of growth, the higher is the percent mortality when the tree is injected with an 8-ounce dosage of copper sulphate. Further cor-

relations of growth and mortality have been made in tables XIV and XV.

TABLE XIV

MORTALITY VS. AGE OF ATTACK AND RATE OF GROWTH FOR ALL LIGHT-DOSAGE TREES

Rings last half-inch	Age of Attack in Days					
	1-25	No. trees	26-50	No. trees	51+	No. trees
41+	100	30	99.3	23	99.5	14
21-40	99.3	54	98.7	27	87.9	31
1-20	95.1	41	82.2	19	79.2	17

TABLE XV

MORTALITY VS. AGE OF ATTACK AND RATE OF GROWTH FOR TREES WITH MORTALITY LESS THAN 100%

Rings last half-inch	Age of Attack in Days					
	1-25	No. trees	26-50	No. trees	51+	No. trees
41+			85	1	93	1
21-40	90.7	4	91.5	4	41.6	6
1-20	75.2	8	58.1	8	52.7	8

It is obvious in tables XIV and XV that growth is an important criterion in determining mortality. The natural assumption would be that the more rapidly-growing trees would take up the poison solution more rapidly than slower-growing trees, and thus result in higher mortality to bark-beetle broods. The higher mortality, however, did not occur in the more rapidly growing trees, as shown in the preceding

three tables. There are then two possible theories which can be offered as to the reason for the effect of growth upon mortality. First, it is possible that the more rapidly growing trees did take up the poison quicker, and in fact, did it so rapidly and thoroughly that with the light dosages used, a considerable quantity of poison was lost in the branches, leaves, and upper, uninfested stem. This is somewhat contradicted, however, when one considers that the correlation between mortality and growth holds true for both young and old attacks alike. Thus it is difficult to visualize an old, heavily blue stained tree taking the poison up so rapidly and thoroughly that the heaviest concentration is at the top of the tree. Yet, this may have been the case.

The second possibility concerns itself with blue stain development and cell structure of slow-growing and rapidly growing trees. It is known that slow-growing trees produce small, thick-walled cells with smaller and more abundant tracheids in the xylem tissue. More rapidly growing trees, on the other hand, produce larger, thinner-walled cells. This mechanical feature is not only expressed in cell structure, but in the relative amounts of active sapwood as well. That is, the xylem remains active for a certain period only and thus the faster growth, with its larger cells and wider growth rings would maintain considerably more active sapwood. Considering this mechanical feature then, with the knowledge that the blue stain fungi are decellulosers, it appears logical that blue stain development would be slower

in slow-growing trees because the more numerous, thick-walled cells of these trees would offer considerably more obstruction to the blue stain than would the larger thin-walled cells of more rapidly growing trees.

Table XVI has been arranged to show the average number of rings for various penetrations of blue stain. The depths of blue stain were taken from the increment cores extracted at the five-foot height on the tree.

TABLE XVI

GROWTH RINGS VS. BLUE STAIN PENETRATION

Blue stain penetration in inches	1/4	1/2	3/4	1+
Average number rings last half-inch wood	25.6	25.5	22.2	17.9
No. trees	12	36	53	139

Although table XVI is not particularly definite, it does indicate that the second theory has considerable in its favor. Undoubtedly, age of attack has a considerable influence on this correlation and to a large extent prevents it from being more positive.

From the preceding tables and discussions then, it may be said that the mortality secured from medication with 8 ounces of copper sulphate and four quarts of water is dependent upon the volume of blue stain

hyphae in the tracheids. The volume of blue stain in turn is dependent upon a number of factors, most important of which are age of the attack and rate of tree growth. In table XVII a single correlation is made between mortality and blue stain. Blue stain in this table was determined only at the point of injection and at the time of injection.

TABLE XVII

MORTALITY VS. BLUE STAIN

	Blue Stain			
	None	Light	Medium	Heavy
Average percent mortality for all trees	98.4	98.0	89.6	84.8
No. trees in group	111	50	70	24
Average percent mortality for trees under 100%	83.1	80.4	57.4	54.6
No. trees in group	10	5	17	8
Percent trees under 100%	9	10	24.2	33.3

It is obvious in table XVII that blue stain is the most important limiting factor discussed so far. Previous discussion has shown that of all factors recorded for the 1935 medicated trees, age of attack, growth rate, diameter, and blue stain are the most important ones influencing the distribution of copper sulphate in the trees. Age of attack and growth rate are merely other ways of expressing blue stain. Hence, with the 255 light-dosage trees under discussion, an

excellent relationship should be shown if mortality is correlated with diameter and blue stain. This correlation is shown in table XVIII.

TABLE XVIII

MORTALITY VS. BLUE STAIN AND DIAMETER

Number of individuals in each group shown in parentheses in the upper right corner of each square.

D.B.H. in inches	Blue Stain: None	Light	Medium	Heavy
4-9.9	(25) 100	(12) 100	(12) 100	(2) 100
10-15.9	(50) 98.6	(27) 98.5	(36) 92.8	(17) 89.7
16-21.9	(31) 97.3	(11) 94.5	(12) 76.6	(7) 82.0
22-27.9	(6) 96.8		(5) 71.4	(2) 91.5

Although the expected relationship is partially shown in table XVIII, there are irregularities in the averages representing the larger diameters and heavier concentrations of blue stain. It is entirely possible that owing to the difficulty of making an accurate visual determination of blue stain, particularly from surface observation only, that the blue stain ratings may be sufficiently inaccurate to cause these irregularities. The errors would probably be most noticeable in the older attacks in which blue stain has had a longer time to develop, and it is there that the irregularities appear in table XVIII.

After examining the increment cores from the medicated trees, however, it appears more logical to assume that the irregular development

of blue stain within the tree accounts for the irregularities under discussion. Increment cores from 81 medicated trees were examined for visual blue stain. Of these trees 24 had heaviest blue stain development at the five-foot examination; 5 had equally heavy stain up to 25 feet; 27 had heaviest development at 25 feet; 4 had equally heavy development at the 25- and 45-foot examinations; 13 had heaviest development at 45 feet; 1 was heaviest at 75 feet; 2 had the same amount of development up to 45 feet; 1 had no blue stain; 1 had heavy blue stain at 5 feet, light development at 25 feet, and heavy again at 45 feet; 1 had heavy stain up to 25 feet, light at 45 feet, and heavy at 65 feet; 1 was heavy at 45, lighter at 65, and heavy again at 75; and 1 was heavy at 5, no stain at 25, with light blue stain at 45 and 65.

Although not infallible, blue stain concentration coincided fairly well with areas of living bark-beetle brood in the 40 light-dosage trees which did not show 100 percent mortality. For example, tree 268 showed light blue stain and no brood at the base of the tree, heavy blue stain and 3 beetles per square foot at 25 feet, and medium to light blue stain with no living brood to the height of infestation. This held fairly true for most of the 40 low-mortality trees. It was also noted in examining the cores from the 255 light-dosage trees that in 197 of them blue stain was heaviest both in color and penetration on the south side of the tree.

From the preceding discussion then, it may be said that with the light dosages used for the 1935 medications, diameter influenced, to a certain extent, the mortality secured. Blue stain, however, was the most important factor in determining the amount of mortality. Blue stain development, on the other hand, is irregular and is influenced by rate of tree growth and age of attack. Furthermore, the irregular development within individual trees is probably owing to intensity of inoculation by the beetles and variability in sunlight along the stem of the tree.

CONCLUSIONS

Considering all medication work in western white pine up to the present time the following general conclusions may be made:

1 - Western white pine trees infested with the mountain pine beetle can be injected with toxic solutions which under certain conditions result in mortality to the bark-beetle broods beneath the bark.

2 - Copper sulphate is the most satisfactory poison tested to date.

3 - The saw-kerf, tin-collar method of injections is the most feasible method of injection tested to date.

4 - Trees injected with 8 ounces of copper sulphate dissolved in four quarts of water by the saw-kerf, tin-collar method show varying amounts of mortality, depending upon the size of the tree and the amount of blue stain in the tree, with possibly other factors. The average

mortality for the 280 trees tested was 95.1 percent.

5 - Blue stain development is irregular and dependent upon several factors, the main ones of which are age of the attack and rate of growth of the tree.

6 - Trees with attacks up to 100 days old and growth showing over 40 rings in the last half inch of wood show an average mortality over 99 percent. Trees of any growth rate with attacks not over 25 days old show an average mortality over 95 percent. Trees with attacks over 60 days old and growth rate showing less than 40 rings in the last half inch of wood show a variable mortality with the average over 79 percent.

7 - Economically, tree medication is superior to present control methods in western white pine. On tree-medication projects to date the production per treating-man-day is three times greater than that secured by decking and burning infested trees. In addition, trees can be medicated at any time during the season, and no fire danger results.

INCREMENT CORES FOR ANALYSIS

Increment cores from 93 trees have been sent to Dr. Wilford for analysis. These cores represent the following groups:

Age of Attack

The cores in this group represent variable age of attack, with a constant diameter of 16-18 inches and a constant mortality of 100

percent to determine the effect of age on distribution. Cores were sent as follows:

Tree Numbers Sent

394	260	395
431	304	267
294	197	203
202	277	274
437	187	427
297	362	155
373	315	374
156	329	263
286		
317	235	236

Mortality

These cores represent variable mortality with a constant diameter of 10-18 inches. Inasmuch as so few trees showed low mortality, a wider range in diameter was necessary and no consideration could be given to age of attack. Cores were sent as follows:

Tree Numbers Sent

250	262	273	355	356
393	371	290	325	342
334	385	318	319	320

Diameter

These cores represent a variable diameter with a constant age

of attack from 6-12 days, and a constant mortality of 100 percent. These cores are to determine the effect of diameter on distribution of copper sulphate. Cores were sent as follows:

Tree Numbers Sent

436	240	400
447	257	248
154	448	451
215	432	434
216	452	249
157	270	450
449	453	261
192	269	433
191		

Dosage

The cores in this group represent trees which were medicated with heavier dosages than the remaining trees. Five of the trees in this group were treated on a commercial wood-preservation basis, using the formula 8 ounces copper sulphate, one quart of water for every cubic foot of wood to be treated. In these trees it was planned to treat the outer two inches of wood. Cores were sent as follows:

Amount copper sulphate	Tree Nos. sent				
32 ounces	149	213	221		
24 "	151	153	188		
16 "	143	189	258		
8 "	144	145	146		
Commercial dosage	351	350	349	348	345

In addition to the above, cores were sent from trees numbered 313 and 378, which were green trees, to determine the distribution in green trees. Cores were sent from trees numbered 233, 282, 280, 279, and 360, which were trees containing living brood below the collar, and from which cores had been extracted below the collar. Extra long 2-inch cores were sent from tree number 393 in order to determine the amount of copper in back of the blue stain. In this tree all of the brood had been killed except at the mid-point along the stem, and it was thought that the poison may have gone up in back of the stain before coming to the surface.

SUGGESTIONS FOR THE 1936 PROJECT

During the 1936 work it appears advisable to concentrate on three phases of this problem. First, it is advisable to see if the results of the 1935 work can be duplicated during 1936 on a smaller scale and with each tree accurately labeled as to date of attack. To determine the exact date of attack one man is now cruising an area in Cascade Creek on the Coeur d'Alene National Forest. In all probability he will be assisted later by one man and the area will be cruised 100 percent periodically. Considering this phase of the problem, it also appears advisable to test various depths of saw-kerf to determine if a better distribution can be secured in older trees by deepening the saw-kerf so as to pass the poison up behind the blue stain, and allow it to diffuse radially to the surface.

The second point to be considered is the medication of trees on a commercial wood-preservation basis, using the formula 8 ounces of copper sulphate to one quart of water for every cubic foot of wood to be medicated. In doing this only the outer inch of wood will be used to compute the volume to be medicated.

The third and final point to be considered is the method of injection. Among the methods to be tested are: rubber bands, paper collars, tin collars coated with organic paint, revised root injection, and paper cups.

Respectfully submitted,

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